Killam

GROUNDWATER/DNAPL/LNAPL MONITORING PLAN

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Former Hexcel Corporation Facility
Lodi, New Jersey

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1.0 INTRODUCTION

In a letter dated March 5, 1992, the New Jersey Department of Environmental Protection and Energy (NJDEPE) required Hexcel to institute a formal monitoring program addressing groundwater elevations, and the Light Non-Aqueous Phase Liquids (LNAPL) and Dense Non-Aqueous Phase Liquids (DNAPL) noted in some of the monitoring wells at the Hexcel site in Lodi, New Jersey. This report fulfills the requirements of the NJDEPE letter dated September 10, 1992 requesting that a "monitoring program for the evaluation of the effectiveness of the shallow overburden remedial system" be prepared.

Specific components of the program required by the Department include monitoring and documenting on a regular basis, the thickness of LNAPL and DNAPL in designated wells, tracking and documentation of the LNAPL/DNAPL recovery effort, and measurement of groundwater elevation. The Department requested the measurement of DNAPL and LNAPL on a monthly basis, and the measurement of groundwater elevation on a quarterly basis. More frequent measurement of groundwater elevation was required by the Department upon initiation of the groundwater recovery system. This information is to be reported to the Department on a monthly basis. In addition to the monitoring of LNAPL and DNAPL, the Department requested that the recovery effort be expanded to include monitoring well CW-7 (LNAPL) and RW7-4 (DNAPL). The Department has required the submittal of a monitoring plan describing the specifics of the program such as identification of the wells which will be monitored and procedures to be followed.

This document presents the specifics of the monitoring plan. The wells which have been selected for monitoring are identified herein, as is the basis for the selection of these wells. The general procedures to be followed in the field and the documentation/reporting format are also described.

2.0 MONITORING PROGRAM

The groundwater/LNAPL/DNAPL monitoring and recovery program, which will go into effect upon approval by the NJDEPE, is described in the following sections.

2.1 Groundwater Elevation Monitoring

In order to monitor the hydraulic performance of the groundwater recovery system, which will be activated upon receipt of the necessary permits, a regular groundwater elevation monitoring program will be implemented.

Currently, a total of seventy-two (72) groundwater monitoring and groundwater/LNAPL/DNAPL recovery wells and two (2) piezometers currently exist at the site. The Department has requested that groundwater level measurements be obtained from all wells at the site. However, it should be noted that many of the wells (especially the control wells) are very close together, and thus do not show appreciable variations in water levels between wells. As such, there is little value in collecting data from every single well. According to the NJDEPE Field Sampling Procedures Manual for May, 1992, when obtaining water measurements, the complete round of measurements should be collected within one day. Furthermore, it is also important to complete the round of water level measurement in as short a time span as possible due to changes in precipitation, river level, and atmospheric pressure changes. Given the large number of wells at the site, and the fact that the field work is to be performed by the trained on-site technician retained by Hexcel, an attempt to collect data from all the wells on the site, within a reasonably short interval of time, is not practical. Keeping these facts in mind, a total of forty eight (48) wells/piezometers and one river staff gauge have been selected for regular groundwater level monitoring. These wells have been selected to give adequate coverage of the entire property. The wells selected include CW-1, CW-2, CW-6, CW-7, CW-8, CW-10, CW-13, CW-22, MW-1 through MW-33, RW1-1, RW6-1, RW7-8, RW15-1, RW15-2, P-1, and P-2 (see Figure 1 in Appendix B). Additionally, the staff gauge installed at the southwest corner of the property will be monitored.

It is proposed that groundwater elevation monitoring take place on a quarterly basis after a satisfactory zone of capture has been established by the groundwater recovery system, and on a monthly basis prior to that. In the first few weeks of the groundwater recovery system operation, it is expected that additional groundwater elevation measurements may be required, as dictated by the system's performance. These data will be utilized to estimate hydraulic contours and provide documentation of the effects of pumping on both the lower overburden and the upper overburden aquifer.

The measurements will be made with a hydrocarbon/water interface probe to an accuracy of the nearest 100th of a foot. The measurements will be made in general conformance with ASTM Method D 4750-87 (Standard Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well), a copy of which is attached as Appendix A. The measurements will be taken by a trained technician retained by Hexcel. An effort will be made to collect all the measurements within a 24 hour period. The data will be reviewed by Killam and presented to the Department in tabular form.

The interface probe's batteries and its proper operation will be checked before each monitoring episode. The probe will be decontaminated between each well by wiping with clean paper towels, washing with laboratory grade detergent, rinsing with tap water followed by a distilled/deionized water rinse. (Please note that the probe is unable to be decontaminated with acetone since damage may occur to the probe when using this solvent.)

Measurements noted will include depth to water, groundwater elevation, date and time. The preceding information will be noted on a form as shown in Figure 2. This information will be submitted to the Department as part of the monthly progress report.

2.2 DNAPL Monitoring and Removal

2.2.1 Occurrence and Current Recovery Effort

The primary constituents of the DNAPL identified at the site include tetrachloroethene, trichloroethene, chlorobenzene, and methylene chloride. Measurable quantities of DNAPL have been found in monitoring wells located between

HEXCEL PROJECT, LODI, NJ
LNAPL/GROUNDWATER MONITORING FORM

DATE:______________________ RECORDED BY: ______________________
WEATHER CONDITIONS:____

Well No.	TOC Elevation (ft, NJVD)	Depth to Water (ft)	Depth to LNAPL/ DNAPL	Total Well Depth (From TOC)	Elev. of Top of Screen (ft, NJVD)	Water Elevation (ft, NJVD)	Thickness of LNAPL/ DNAPL	Date/ Time of Day	Remarks
MW-1	32.42								
MW-2	31.00								
MW-3	31.13								
MW-4	32.28								
MW-5	32.50								
MW-6	30.70								
MW-7	30.68								
MW-8	30.26								
MW-9	29.83								
MW-10	30.83								
MW-11	30.78								
MW-12	31.01								
MW-13	31.16								
MW-14	30.70								

Note: The Total Well Depth (From TOC) and the Elev. of Top of Screen will be determined during the first monitoring episode.

CHECKED BY:__________, DATE:__________

FIGURE 2

HEXCEL PROJECT, LODI, NJ
LNAPL/GROUNDWATER MONITORING FORM
(Continued)

Well No.	TOC Elevation (ft, NJVD)	Depth to Water (ft)	Depth to LNAPL/ DNAPL	Total Well Depth (From TOC)	Elev. of Top of Screen (ft, NJVD)	Water Elevation (ft, NJVD)	Thickness of LNAPL/ DNAPL	Date/ Time of Day	Remarks
MW-15	30.77								
MW-16	29.69								
MW-17	31.53								
MW-18	32.23								
MW-19	29.08								
MW-20	27.95								
MW-21	30.67								
MW-22	28.36								
MW-23	27.29								
MW-24	26.12								
MW-25	26.03								
MW-26	28.88								
MW-27	31.43								
MW-28	29.68								

Note: The Total Well Depth (From TOC) and the Elev. of Top of Screen will be determined during the first monitoring episode.

CHECKED BY:___________, DATE:___________

FIGURE 2

HEXCEL PROJECT, LODI, NJ
LNAPL/GROUNDWATER MONITORING FORM
(Continued)

Well No.	TOC Elevation (ft, NJVD)	Depth to Water (ft)	Depth to LNAPL/ DNAPL	Total Well Depth (From TOC)	Elev. of Top of Screen (ft, NJVD)	Water Elevation (ft, NJVD)	Thickness of LNAPL/ DNAPL	Date/ Time of Day	Remarks
MW-29	27.06								
MW-30	27.95								
MW-31	27.95								
MW-32									
MW-33									
CW-1	29.77								
CW-2	29.51								
CW-6	28.93								
CW-7	26.13								
CW-8	26.77								
CW-10	25.91								
CW-13	26.05								
CW-22	26.35								
RW1-1									

Note: The Total Well Depth (From TOC) and the Elev. of Top of Screen will be determined during the first monitoring episode.

CHECKED BY:__________, DATE:__________

FIGURE 2

HEXCEL PROJECT, LODI, NJ
LNAPL/GROUNDWATER MONITORING FORM
(Continued)

Well No.	TOC Elevation (ft, NJVD)	Depth to Water (ft)	Depth to LNAPL/ DNAPL	Total Well Depth (From TOC)	Elev. of Top of Screen (ft, NJVD)	Water Elevation (ft, NJVD)	Thickness of LNAPL/ DNAPL	Date/ Time of Day	Remarks
RW6-1	28.84								
RW7-8	25.90								
RW15-1	28.89								
RW15-2	30.13								
P-1									
P-2									

Note: The Total Well Depth (From TOC) and the Elev. of Top of Screen will be determined during the first monitoring episode.

CHECKED BY:___________ , DATE:_____________

FIGURE 2

Building No. 2 and the Saddle River. The DNAPL is present at the bottom of the upper overburden aquifer, which is composed of fill and glacial alluvial sand and gravel. The aquifer is underlain by a low permeability silty clay layer which occurs at a depth of seven to seventeen feet below grade. Based on historical DNAPL measurements, the limits of recoverable DNAPL lie approximately in the area delimited by RW7-8 and RW7-10 on the south, and RW7-5 to the north (see Figure 1).

A review of all monitoring well logs, boring logs, and historical product measurements was conducted to identify the wells requiring regular monitoring for the presence of DNAPL. Historical observations of DNAPL are summarized in Table 1. As seen in Table 1, wells that have in the past shown the presence of a discrete detectable layer of DNAPL at least once include RW7-1, RW7-2, RW7-3, RW7-4, RW7-5, MW-6, MW-8, CW-15, CW-16, and MW-27. Of these 10 wells, the five wells that have previously shown significant accumulations of DNAPL are RW7-1, RW7-4, RW7-5, MW-6 and MW-8. The other five wells (RW7-2, RW7-3, CW-15, CW-16, and MW-27) have only shown a trace of DNAPL on one or two occasions. Although the logs for monitoring wells MW-28, CW-1, CW-3, CW-4, CW-5, CW-14, RW6-1, RW6-2, RW7-6, RW7-8, RW7-9, and RW7-10 record odors in these locations at depth, no DNAPL has ever been noted in these wells. Note that odors were not observed during the installation of RW7-7 located north of RW7-9, and CW-17 through CW-22 along the Saddle River (as seen in Figure 1), indicating the decreasing trend of DNAPL presence.

It should be noted that, according to Hexcel's former consultant Heritage Remediation/Engineering, the RW7 series wells were installed such that there is a 2 foot sump constructed into the silty clay unit. Therefore, the thickness of DNAPL in the RW7 series wells is not a true indicator of the DNAPL thickness in the formation.

Pneumatic DNAPL recovery pumps are permanently installed in RW7-1 and RW7-5. In addition to RW7-1, and RW7-5, DNAPL has also reportedly been recovered from wells MW-6, MW-8, RW7-4, and CW-15, using a retrievable brass pump and controller by Heritage. These wells were pumped until no DNAPL was seen in the discharge, allowed to stand, and pumped again until no measurable DNAPL was present in the well. According to Heritages's estimate, approximately 1250 gallons of DNAPL has been

TABLE 1
HISTORICAL DNAPL OCCURANCE

Well No.	Date	DNAPL THICKNESS (ft.)	COMMENT
RW7-1	8/28/90 6/7/91 10/15/91 3/18/92	≈ 5 - - none in discharge	bailed pump pump pump
RW7-2	8/28/90 6/7/91 3/18/92	trace ND ND	bailed - -
RW7-3	8/28/90 6/7/91 10/28/91 3/18/92	trace trace ND ND	bailed - - -
RW7-4	8/28/90 6/7/91 8/6/91 10/15/91 10/21/91 3/18/92	≈ 4 2.50 0.73 0.95 0.75 0.33	bailed - - - after DNAPL removal -
RW7-5	8/28/90 9/25/91 9/26/91 9/27/91 9/28/91 10/3/91 10/10/91 3/18/92	4 - 5 4.17 3.90 3.73 3.57 3.40 3.35 none in discharge	bailed recovery system pilot test on RW7-5 pump pump pump pump pump
MW-6	6/7/91 8/6/91 10/15/91 10/21/91 3/18/92	0.20 1.20 1.23 0.38 1.44	- - - after DNAPL removal -
MW-8	6/7/91 8/6/91 10/15/91 10/21/91 3/18/92	0.50 1.58 1.56 0.49 0.65	- - - after DNAPL removal -
CW-15	8/22/90 6/7/91 10/21/91 3/18/92	trace ND ND ND	- - - -
CW-16	8/22/90 6/7/91 10/21/91 3/18/92	trace ND ND ND	- - - -
MW-27	6/7/91	trace	-

Notes:
1. As reported by Heritage Remediation/Engineering

recovered to date. Heritage reports that currently, RW7-1 and RW7-5 do not contain enough DNAPL to automatically actuate the pumps. Therefore, these pumps are operated periodically by Hexcel's on-site operator to recover total fluids, at an approximate rate of 0.5 gpm per well. Heritage estimates that this discharge is approximately 1 to 10 percent DNAPL. The discharge is pumped into a 500-gallon above ground storage tank with secondary containment. DNAPL is allowed to separate by gravity from the water in the tank. The separated DNAPL phase is properly disposed off-site, while the water is treated ~~in the groundwater treatment~~ system and discharged to the sanitary sewer.

2.2.2 Proposed Monitoring and Recovery

Based on the above discussion, it is proposed that a total of twenty (20) wells be included in the DNAPL monitoring program. These wells include MW-6, MW-8, MW-27, MW-28, CW-3, CW-4, CW-5, CW-14, CW-15, CW-16, RW6-1, RW6-2, RW7-2, RW7-3, RW7-4, RW7-6, RW7-7, RW7-8, RW7-9, RW7-10. These wells have been selected on the basis of either a historical occurrence of DNAPL, or their proximity to the known location of DNAPL. It is proposed that all twenty wells identified be checked for the presence of DNAPL on a monthly basis, for the first three months following the initiation of the groundwater recovery operation. These data would provide adequate information on the location of recoverable DNAPL, as well as show any effect that the groundwater pumping operation may have on the DNAPL accumulation. Following these first three months of monitoring, the wells that have not shown any DNAPL presence in six consecutive episodes (six consecutive episodes refer to the first three months after initiation plus the three monitoring episodes previously completed by Heritage) will thereafter be monitored on a yearly basis. The remaining wells will continue to be monitored on a monthly basis. If any of these wells monitored on a monthly basis shows no DNAPL presence for six consecutive episodes, then this well will be monitored on a yearly basis. If a well that is monitored on a yearly basis (once per calendar year) shows the presence of DNAPL during any single monitoring episode, it will be reinstated into the monthly monitoring program.

Note that two wells where DNAPL has been documented (RW7-1, and RW7-5) cannot be included in this routine monitoring program because these wells have DNAPL pumps permanently installed in them, and are therefore not accessible for direct DNAPL measurement. However, an indirect assessment of DNAPL presence, such as the volume of DNAPL recovered from these wells during each total fluids recovery episode will be included in the monitoring program.

All wells that show recoverable amounts of DNAPL will be pumped on a monthly basis. The wells will be pumped using a retrievable brass, bottom fill, pneumatic pump placed at the bottom of the well. It is expected that the wells will be pumped at an approximate rate of 0.5 gpm. The wells will be pumped until no DNAPL is observed in the discharge, allowed to recover for 2 hours and then pumped again until no measurable DNAPL is observed in the well. The recovered fluid will be pumped to the 500 gallon above ground tank, where the DNAPL will be allowed to separate from the water. The DNAPL will be properly disposed off-site, while the water will be processed through the groundwater treatment system. The pumps installed in RW7-1 and RW7-5 will continue to be operated as before, at a frequency of at least once a month. An effort will be made to adjust the total fluid recovery pumps in these wells such that the pumps are placed at the bottom of the well.

In addition to the above noted actions, the two lower overburden aquifer wells MW-7 and MW-9, which are located in proximity to the DNAPL in the upper overburden aquifer, will be checked for the presence of volatile organic vapors with an HNu during the first monitoring episode. This will be done in order to further document that the integrity of the well casings has not been affected by the DNAPL.

2.2.3 Field Procedures, Documentation, and Reporting

The measurement of DNAPL thickness will be made with a hydrocarbon/water interface probe to an accuracy of the nearest 100th of a foot. The measurements will be made in general conformance with ASTM Method D 4750-87 (Standard Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well), a copy of which is attached as Appendix A. The measurements will be made by a trained technician retained by Hexcel. An effort will be made to collect all the measurements within a 24 hour period. The data will be reviewed by Killam before presentation to the Department.

The interface probe's batteries and its proper operation will be checked before each monitoring episode. The probe will be decontaminated between each well by wiping with clean paper towels, washing with laboratory grade detergent, rinsing with tap water followed by a distilled/deionized water rinse.

Level D protection will be utilized during DNAPL measurement. Details of the monitoring Health and Safety procedures have been submitted previously by Heritage in the Health and Safety Plan dated June 1991.

Measurements noted will include depth to product, depth to water, thickness of product, date and time. The preceding information will be noted on a form as shown in Figure 3 (Please note that information on this form which is not listed will become available after completing the first monitoring episode). This information will be submitted to the Department on a monthly basis, as part of the monthly progress report.

The DNAPL recovery effort will be documented on a form as shown in Figure 4. This information will be submitted to the Department on a monthly basis, as part of the monthly progress report.

2.3 LNAPL Monitoring and Removal

2.3.1 Occurrence and Current Recovery Effort

The LNAPL identified at the site consists of petroleum hydrocarbon compounds with some chlorinated organic compounds including polychlorinated biphenyls (PCBs). The primary constituents of the LNAPL are diesel fuel and/or No. 2 fuel oil. Measurable thicknesses of LNAPL have been found in monitoring wells located in the Boiler Room (Building No. 1) and west of Building No. 1. The floating LNAPL is present in the upper overburden aquifer composed of fill and glacial alluvial sand and gravel.

Based on historical LNAPL measurements, a measurable layer of LNAPL has only been found in one well (CW-7) and one piezometer (P-2) shown in Figure 1. Traces of LNAPL were observed in MW-17, MW-18, MW-23, MW-29, CW-12 and CW-13 on one or two

HEXCEL PROJECT, LODI, NJ
DNAPL MONITORING FORM

Well No.	TOC Elevation (ft, NJVD)	Depth to Water (ft)	Depth to DNAPL	Total Well Depth (From TOC)	Water Elevation (ft, NJVD)	Thickness of DNAPL	Date/ Time of Day	Remarks
RW7-2	26.48							
RW7-3	26.78							
RW7-4	27.11							
RW7-6	26.48							
RW7-7	26.89							
RW7-8	25.90							
RW7-9	26.87							
RW7-10	26.08							
RW6-1	28.84							
RW6-2								
MW-6	30.70							
MW-8	30.26							
MW-27	31.43							
MW-28	29.68							

Note: The Total Well Depth (From TOC) will be determined during the first monitoring episode.

CHECKED BY:__________, DATE:__________

FIGURE 3

HEXCEL PROJECT, LODI, NJ
DNAPL MONITORING FORM

Well No.	TOC Elevation (ft, NJVD)	Depth to Water (ft)	Depth to DNAPL	Total Well Depth (From TOC)	Water Elevation (ft, NJVD)	Thickness of DNAPL	Date/ Time of Day	Remarks
CW-3								
CW-4	29.00							
CW-5	28.67							
CW-14	26.37							
CW-15	26.31							
CW-16	26.45							

Note: The Total Well Depth (From TOC) will be determined during the first monitoring episode.

CHECKED BY:___________ , DATE:___________

FIGURE 3

HEXCEL PROJECT, LODI, NJ
PRODUCT RECOVERY FORM

DATE:____________ RECORDED BY: ____________
WEATHER CONDITIONS:____________

DNAPL RECOVERY

Location:________

Depth to water (prior to pumping):________ ft.

Depth to DNAPL (prior to pumping):________ ft. Thickness of DNAPL:______ft.

Pump rate:______ gpm
Volume of liquid pumped (first round):_______gal.
Duration of pumping (first round):________ hrs.

Depth to water (after 1st round of pumping):________ ft.

Depth to DNAPL (after 1st round of pumping):________ ft. Thickness of DNAPL:______ft.

Pump rate:______ gpm
Volume of liquid pumped (second round):_______gal.
Duration of pumping (second round):________hrs.

Depth to water (after 2nd round of pumping):________ ft.

Depth to DNAPL (after 2nd round of pumping):________ ft. Thickness of DNAPL:______ft.

Estimated percentage of DNAPL in Liquid:________

Estimated Volume of DNAPL Recovered:________ gal.

LNAPL RECOVERY

Passive Recovery

Location:________

Depth to water (prior to removing skimmer from well):________ ft.
Depth to LNAPL (prior to removing skimmer from well):________ ft.
Thickness of LNAPL:______ft.
Estimated volume of LNAPL recovered from skimmer:________ gal.

Permanently Installed LNAPL Recovery System

Estimated additional LNAPL in drum since last observed:______ gal.
Estimated volume of LNAPL recovered:________ gal.

SIGNATURE:________ , DATE:________

occasions. Traces of oil were noted on the drill cuttings in MW-30 and RW1-1, while odors were observed during well installation at MW-21, MW-24, CW-1 through CW-5, CW-8, CW-10, and CW-14. However, none of these wells have shown an accumulation of LNAPL. Table 2 summarizes the historical LNAPL measurements and well log observations.

Heritage has previously reported that during a pump test conducted in CW-5, the discharge from the well was noted to have a white appearance and a "solvent" odor. Upon standing for several hours in a tank, a trace of "dark oil" separated from the water. The oil was fingerprinted and found to have no similarities to the product found in the other wells on the site, which was characterized as having a chromatographic pattern similar to No. 2 fuel oil. It was suggested by Heritage that the material is present in emulsion in the soils and separates only when present as free standing liquid outside of the soil matrix. Note that this well is part of the groundwater recovery system that will be activated upon receipt of the necessary permits.

A pneumatic groundwater drawdown pump and LNAPL recovery pump are installed in RW15-1 and RW15-2. The water from these two wells discharges into two 1,650 gallon tanks (H-4 and H-5) which are part of the groundwater treatment system, while the LNAPL is discharged to a 55-gallon drum. Currently, no LNAPL is present in these wells, although two piezometers located in the same area have shown a measurable layer of floating LNAPL product. Upon activation of the groundwater recovery and treatment system, the groundwater table depression pumps will be activated to facilitate the flow of LNAPL into these wells. LNAPL has been pumped directly from CW-7 by Heritage. According to Heritage's estimate, approximately 130 gallons of LNAPL have been recovered to date.

2.3.2 Proposed Monitoring and Recovery

It is proposed that the LNAPL monitoring program include all of the wells that are targeted for groundwater elevation measurement. Since a hydrocarbon/water interface probe will be utilized for the measurement of groundwater elevation measurement, the

TABLE 2
HISTORICAL LNAPL OCCURANCE

Well No.	Date	LNAPL THICKNESS (ft.)	COMMENT
MW-18	6/18/91	ND	-
	7/26/91	ND	-
	4/9/92	trace	-
MW-23	11/10/90	sheen	-
	6/18/91	trace	-
	7/26/91	ND	-
	4/8/92	0.02	-
MW-29	2/12/91	ND	-
	6/18/91	sheen	-
	7/26/91	ND	-
	4/8/92	ND	-
MW-30	2/12/91	sheen	-
	6/18/91	ND	-
	7/26/91	ND	-
	4/8/92	ND	-
MW-31	2/12/91	ND	-
	6/18/91	ND	-
	7/26/91	ND	-
	4/8/92	ND	-
CW-7	6/18/91	3.15	bailed
	8/29/91	2.14	-
	9/17/91	1.89	removed by bailing
	3/18/92	trace	-
	4/9/92	0.16	-
CW-8	8/29/91	ND	-
	9/17/91	ND	-
	4/9/92	ND	-
RW15-1	10/3/90	ND	-
	12/13/90	ND	-
	8/29/91	ND	-
	3/18/92	ND	-
RW15-2	10/3/90	ND	-
	12/13/90	ND	-
	8/29/91	ND	-
	3/18/92	ND	-
RW1-1	10/16/91	ND	-
	3/18/92	ND	-
P-1	10/3/90	0.10	-
	12/13/90	0.08	-
	8/29/91	0.38	removed by pumping
	3/18/92	trace	-
P-2	10/3/90	ND	-
	12/13/90	ND	-
	8/29/91	ND	-
	3/18/92	ND	-

Notes:
1. As reported by Heritage Remediation/Engineering

LNAPL check/measurement can be accomplished at the same time as the groundwater elevation measurement. All of the wells that have any history of LNAPL occurrence or are in proximity to known LNAPL areas are included in this proposal.

It is proposed that LNAPL monitoring take place at the same frequency as the groundwater elevation measurement, i.e. on a quarterly basis after a satisfactory zone of capture has been established by the groundwater recovery system, and on a monthly basis prior to that. In the first few weeks of the groundwater recovery system operation, groundwater elevation measurements are proposed on a more frequent basis, as dictated by the system's performance. These data are expected to provide adequate information on the effects of the pumping operation on the location and mobility of the floating LNAPL product.

It is proposed that a passive free product recovery device (Horner Ezy Skimmer as manufactured by Horner Creative Products Inc.) be installed in CW-7 to continuously collect LNAPL. This device is composed of two elements: an upper unit consisting of a filter element inside a slotted PVC pipe, and a lower unit consisting of a 2" diameter, 24-inch long, clear PVC pipe collection chamber with a ball valve on the lower end to drain the accumulated product. The equipment is designed, when empty, to float in water with about 6 inches of its filter element above the water line, while the remaining lower cylinder assembly provides the buoyancy required. The unit is supported and prevented from sinking by a light chain. The filter element is installed to intersect and continuously collect the floating product (excluding water) until the unit becomes filled, at which point it requires manual draining. The unit will be installed in CW-7 and emptied on a weekly basis until a recovery rate is established. Subsequently, the draining frequency will be adjusted as necessary.

As mentioned before, upon activation of the groundwater recovery and treatment system, the groundwater table depression pumps installed in RW15-1 and RW15-2 will be activated to facilitate the flow of LNAPL into these wells. If any additional wells collect free product in recoverable quantities, units similar to the one described above will be installed in them.

It is possible that the well screens in some of the wells are installed at a depth such that they do not intersect the LNAPL layer (if present). However, the operation of the groundwater recovery system will most likely lower the overall water table in the area of interest so that the floating LNAPL will be within the screened interval. A comparison of the well screen elevation with the LNAPL depth will be made during the monitoring program to ensure that the LNAPL layer is in fact at the screened depth.

2.3.3 Field Procedures, Documentation and Reporting

The measurement of LNAPL thickness will be made with a hydrocarbon/water interface probe to an accuracy of the nearest 100th of a foot. The measurements will be made in general conformance with ASTM Method D 4750-87 (Standard Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well), a copy of which is attached as Appendix A. The measurements will be made by a trained technician retained by Hexcel. An effort will be made to collect all the measurements within a 24 hour period. The data will be reviewed by Killam before presentation to the Department.

The interface probe's batteries and its proper operation will be checked before each monitoring episode. The probe will be decontaminated between each well by wiping with clean paper towels, washing with laboratory grade detergent, rinsing with tap water followed by a distilled/deionized water rinse.

Details of the monitoring Health and Safety procedures have been submitted previously by Heritage in the Health and Safety Plan dated June 1991. Level D protection will be utilized during DNAPL measurement.

Measurements noted will include depth to product, depth to water, thickness of product, date and time. The preceding information will be noted on a form as shown in Figure 2. This information will be submitted to the Department as part of the monthly progress reports.

The LNAPL recovery effort will be documented on a form as shown in Figure 4. This information will be submitted to the Department as part of the monthly progress report.

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APPENDIX A

ASTM Method D 4750-87
Standard Test Method for Determining Subsurface Liquid Levels
in a Borehole or Monitoring Well

Standard Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well)[1]

This standard is issued under the fixed designation D 4750; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method describes the procedures for measuring the level of liquid in a borehole or well and determining the stabilized level of liquid in a borehole.

1.2 The test method applies to boreholes (cased or uncased) and monitoring wells (observation wells) that are vertical or sufficiently vertical so a flexible measuring device can be lowered into the hole.

1.3 Borehole liquid-level measurements obtained using this test method will not necessarily correspond to the level of the liquid in the vicinity of the borehole unless sufficient time has been allowed for the level to reach equilibrium position.

1.4 This test method generally is not applicable for the determination of pore-pressure changes due to changes in stress conditions of the earth material.

1.5 This test method is not applicable for the concurrent determination of multiple liquid levels in a borehole.

1.6 The values stated in inch-pound units are to be regarded as the standard.

1.7 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Document

2.1 *ASTM Standard:*

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[2]

3. Terminology

3.1 *Descriptions of Terms Specific to This Standard:*

3.1.1 *borehole*—a hole of circular cross-section made in soil or rock to ascertain the nature of the subsurface materials. Normally, a borehole is advanced using an auger, a drill, or casing with or without drilling fluid.

3.1.2 *earth material*—soil, bedrock, or fill.

3.1.3 *ground-water level*—the level of the water table surrounding a borehole or well. The ground-water level can be represented as an elevation or as a depth below the ground surface.

3.1.4 *liquid level*—the level of liquid in a borehole or well at a particular time. The liquid level can be reported as an elevation or as a depth below the top of the land surface. If the liquid is ground water it is known as water level.

3.1.5 *monitoring well* (*observation well*)—a special well drilled in a selected location for observing parameters such as liquid level or pressure changes or for collecting liquid samples. The well may be cased or uncased, but if cased the casing should have openings to allow flow of borehole liquid into or out of the casing.

3.1.6 *stabilized borehole liquid level*—the borehole liquid level which remains essentially constant with time, that is liquid does not flow into or out of the borehole.

3.1.7 *top of borehole*—the surface of the ground surrounding the borehole.

3.1.8 *water table* (*ground-water table*)—the surface of a ground-water body at which the water pressure equals atmospheric pressure. Earth material below the ground-water table is saturated with water.

3.2 *Definitions:*

3.2.1 For definitions of other terms used in this test method, see Terminology D 653.

4. Significance and Use

4.1 In geotechnical, hydrologic, and waste-management investigations, it is frequently desirable, or required, to obtain information concerning the presence of ground water or other liquids and the depths to the ground-water table or other liquid surface. Such investigations typically include drilling of exploratory boreholes, performing aquifer tests, and possibly completion as a monitoring or observation well. The opportunity exists to record the level of liquid in such boreholes or wells, as the boreholes are being advanced and after their completion.

4.2 Conceptually, a stabilized borehole liquid level reflects the pressure of ground water or other liquid in the earth material exposed along the sides of the borehole or well. Under suitable conditions, the borehole liquid level and the ground-water, or other liquid, level will be the same, and the former can be used to determine the latter. However, when earth materials are not exposed to a borehole, such as material which is sealed off with casing or drilling mud, the borehole water levels may not accurately reflect the ground-water level. Consequently, the user is cautioned that the liquid level in a borehole does not necessarily bear a relationship to the ground-water level at the site.

4.3 The user is cautioned that there are many factors which can influence borehole liquid levels and the interpretation of borehole liquid-level measurements. These factors are not described or discussed in this test method. The

[1] This test method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

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[2] *Annual Book of ASTM Standards*, Vol 04.08.

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interpretation and application of borehole liquid-level information should be done by a trained specialist.

4.4 Installation of piezometers should be considered where complex ground-water conditions prevail or where changes in intergranular stress, other than those associated with fluctuation in water level, have occurred or are anticipated.

5. Apparatus

5.1 Apparatus conforming to one of the following shall be used for measuring borehole liquid levels:

5.1.1 *Weighted Measuring Tape*—A measuring tape with a weight attached to the end. The tape shall have graduations that can be read to the nearest 0.01 ft. The tape shall not stretch more than 0.05 % under normal use. Steel surveying tapes in lengths of 50, 100, 200, 300, and 500 ft (20, 30, 50 or 100 m) and widths of ¼ in. (6 mm) are commonly used. A black metal tape is better than a chromium-plated tape. Tapes are mounted on hand-cranked reels up to 500 ft (100 m) lengths. Mount a slender weight, made of lead, to the end of the tape to ensure plumbness and to permit some feel for obstructions. Attach the weight to the tape with wire strong enough to hold the weight but not as strong as the tape. This permits saving the tape in the event the weight becomes lodged in the well or borehole. The size of the weight shall be such that its displacement of water causes less than a 0.05-ft (15-mm) rise in the borehole water level, or a correction shall be made for the displacement. If the weight extends beyond the end of the tape, a length correction will be needed in measurement Procedure C (see 7.2.3).

5.1.2 *Electrical Measuring Device*—A cable or tape with electrical wire encased, equipped with a weighted sensing tip on one end and an electric meter at the other end. An electric circuit is completed when the tip contacts water; this is registered on the meter. The cable may be marked with graduations similar to a measuring tape (as described in 5.1.1).

5.1.3 *Other Measuring Devices*—A number of other recording and non-recording devices may be used. See Ref. **(1)** for more details.[3]

6. Calibration and Standardization

6.1 Calibrate measuring apparatus in accordance with the manufacturers' directions.

7. Procedure

7.1 Liquid-level measurements are made relative to a reference point. Establish and identify a reference point at or near the top of the borehole or a well casing. Determine and record the distance from the reference point to the top of the borehole (land surface). If the borehole liquid level is to be reported as an elevation, determine the elevation of the reference point or the top of borehole (land surface). Three alternative measurement procedures (A, B, and C) are described.

NOTE 1—In general, Procedure A allows for greater accuracy than B or C, and B allows for greater accuracy than C; other procedures have a variety of accuracies that must be determined from the reference literature (2–5).

7.2 *Procedure A—Measuring Tape:*

7.2.1 Chalk the lower few feet of tape by drawing the tap across a piece of colored carpenter's chalk.

7.2.2 Lower a weighted measuring tape slowly into th borehole or well until the liquid surface is penetrated Observe and record the reading on the tape at the referenc point. Withdraw the tape from the borehole and observe th lower end of the tape. The demarcation between the wette and unwetted portions of the chalked tape should b apparent. Observe and record the reading on the tape at tha point. The difference between the two readings is the dept from the reference point to the liquid level.

NOTE 2—Submergence of the weight and tape may temporari cause a liquid-level rise in wells or boreholes having very sma diameters. This effect can be significant if the well is in materials of ve low hydraulic conductivity.

NOTE 3—Under dry surface conditions, it may be desirable to pull th tape from the well or borehole by hand, being careful not to allow it t become kinked, and reading the liquid mark before rewinding the tap onto the reel. In this way, the liquid mark on the chalked part of the tap is rapidly brought to the surface before the wetted part of the tape drie In cold regions, rapid withdrawal of the tape from the well is necessa before the wet part freezes and becomes difficult to read. The tape mu be protected if rain is falling during measurements.

NOTE 4—In some pumped wells, or in contaminated wells, a layer o oil may float on the water. If the oil layer is only a foot or less thick, rea the tape at the top of the oil mark and use this reading for the water-lev measurement. The measurement will not be greatly in error because th level of the oil surface in this case will differ only slightly from the lev of the water surface that would be measured if no oil was present. several feet of oil are present in the well, or if it is necessary to know th thickness of the oil layer, a water-detector paste for detecting water in o and gasoline storage tanks is available commercially. The paste applied to the lower end of the tape that is submerged in the well. It w show the top of the oil as a wet line and the top of the water as a distin color change.

7.2.3 As a standard of good practice, the observer shoul make two measurements. If two measurements of stat liquid level made within a few minutes do not agree withi about 0.01 or 0.02 ft (generally regarded as the practical lim of precision) in boreholes or wells having a depth to liquid o less than a couple of hundred feet, continue to measure unt the reason for the lack of agreement is determined or unt the results are shown to be reliable. Where water is drippin into the hole or covering its wall, it may be impossible to ge a good water mark on the chalked tape.

7.2.4 After each well measurement, in areas where po luted liquids or ground water is suspected, decontamina that part of the tape measure that was wetted to avoi contamination of other wells.

7.3 *Procedure B—Electrical Measuring Device:*

7.3.1 Check proper operation of the instrument by in serting the tip into water and noting if the contact betwee the tip and the water surface is registered clearly.

NOTE 5—In pumped wells having a layer of oil floating on the wate the electric tape will not respond to the oil surface and, thus, the liqu level determined will be different than would be determined by a ste tape. The difference depends on how much oil is floating on the water. miniature float-driven switch can be put on a two-conductor electr tape that permits detection of the surface of the uppermost fluid.

[3] The boldface numbers in parentheses refer to the list of references at the end of this standard.

BOREHOLE OR WELL SCHEDULE FORM

Date ____________, 19____ Field No. ________
Record by ____________ Office No. ________
Source of data ____________

1. *Location:* State ________ County ________
Map ________
____ ¼ ____ ¼ sec. ____ T ____ N/S R ____ E/W
2. *Owner:* ________ Address ________
Tenant ________ Address ________
Driller ________ Address ________
3. *Topography* ________
4. *Elevation* ________ ft. above/below ________
5. *Type:* Dug, drilled, driven, bored, jetted ____ 19____
6. *Depth:* Rept. ____ ft. Meas. ____ ft.
7. *Casing:* Diam. ____ in., to ____ in., Type ____
Depth ____ ft., Finish ________
8. *Chief Aquifer* ________ From ____ ft. to ____ ft.
Others ________
9. *Water level* ____ ft. rept./meas. ________ 19____ above/below ________
________ which is ____ ft. above/below surface
10. *Pump:* Type ________ Capacity ________ G. M. ____
Power: Kind ________ Horsepower ________
11. *Yield:* Flow ____ G. M., Pump ____ G. M., Meas., Rept. Est. ____
Drawdown ____ ft. after ____ hours pumping ________ G. M.
12. *Use:* Dom., Stock, PS., RR., Ind., Irr., Obs. ________
Adequacy, permanence ________
13. *Quality* ________ Temp ____ °F.
Taste, odor, color ________ Sample Yes/No ________
Unfit for ________
14. *Remarks:* (Log, Analyses, etc.) ________

FIG. 1 Example of a Borehole or Well Schedule Form

LIQUID LEVEL MEASUREMENT FORM

Field No. ________
Owner ________ Office No. ________
Location ________ Project ________
Measuring Point ________
Elevation of Measuring Point ________

Date	Hour	Depth to Water	Elev. of Water Surface	Meas. by	Remarks (Nearby wells pumping, etc.)

FIG. 2 Example of a Liquid Level Measurement Form

7.3.2 Dry the tip. Slowly lower the tip into the borehole or well until the meter indicates that the tip has contacted the surface of the liquid.

7.3.3 For devices with measurement graduations on the cable, note the reading at the reference point. This is the liquid-level depth below the reference point of the borehole or well.

7.3.4 For measuring devices without graduations on the cable, mark the cable at the reference point. Withdraw the cable from the borehole or well. Stretch out the cable and measure and record the distance between the tip and the mark on the cable by use of a tape. This distance is the liquid-level depth below the reference point.

7.3.5 A second or third check reading should be taken before withdrawing the electric tape from the borehole or well.

7.3.6 Decontaminate the submerged end of the electric tape or cable after measurements in each well.

NOTE 6—The length of the electric line should be checked by measuring with a steel tape after the line has been used for a long time or after it has been pulled hard in attempting to free the line. Some electric lines, especially the single line wire, are subject to considerable permanent stretch. In addition, because the probe is usually larger in diameter than the wire, the probe can become lodged in a well. Sometimes the probe can be attached by twisting the wires together by hand and using only enough electrical tape to support the weight of the probe. In this manner, the point of probe attachment is the weakest point of the entire line. Should the probe become "hung in the hole," the line may be pulled and breakage will occur at the probe attachment point, allowing the line to be withdrawn.

7.4 *Procedure C—Measuring Tape and Sounding Weight:*

7.4.1 Lower a weighted measuring tape into the borehole or well until the liquid surface is reached. This is indicated by an audible splash and a noticeable decrease in the downward force on the tape. Observe and note the reading on the tape at the reference point. Repeat this process until the readings are consistent to the accuracy desired. Record the result as the liquid-level depth below the reference point.

NOTE 7—The splash can be made more audible by using a "plopper," a lead weight with a concave bottom surface.

7.4.2 If the liquid level is deep, or if the measuring tape adheres to the side of the borehole, or for other reasons, it may not be possible to detect the liquid surface using this method. If so, use Procedure A or Procedure B.

8. Determination of a Stabilized Liquid Level

8.1 As liquid flows into or out of the borehole or well, the liquid level will approach, and may reach, a stabilized level. The liquid level then will remain essentially constant with time.

SITE NO.

BOREHOLE OR WELL SCHEDULE FORM

Recorded by ____________________ Date ____________

Check One ____ English ____ Metric Units

GENERAL SITE DATA (0)

Site Ident No. RG Number R • 0 • Transaction T • A D M V • (add, delete, modify, verified)

Site Type 2 • C D E H I M O P S T W X • (collector, drain, excavation, Connector, multiple, outcrop, pond, spring, tunnel, well, test hole, mine, shaft, lake)

Data Reliability 3 • C U • (field checked, unchecked)

Reporting Agency 4 •

Project No. 5 • District 6 • State 7 • County (or town) 8 •

Latitude 9 • (deg min sec) Longitude 10 • (deg min sec) Lat-Long Accuracy 11 • S F T M • (sec, 5 sec, 10 sec, Min)

Local Number 12 • Land Net Loc 13 • S T R (1/4 1/4 1/4 section, township, range, meridian)

Location Map 14 • Scale 15 •

Altitude 16 • Method of Measurement 17 • A L M • (altimeter, level, map) Accuracy 18 •

Topo Setting 19 • A B C D E F G H K L M O P S T U V W • Hydrologic Unit (OWDC) 20 •

Use of Site 23 • A C D E G H M O P R S T U W X Z • Secondary Site Use 301 • Tertiary Site Use 302

Use of Water 24 • A B C D E F H I J K M N P Q R S T U Y Z •

Secondary Water Use 25 • Tertiary Use of Water 26 • Depth of Hole 27 • Depth of Well 28 • Source of Depth Data ① 29 •

Water Level 30 • Date Measured 31 • / / (month day year) Source ① 33 •

Method of Measurement 34 • A B C E G H L M N R S T V Z •

Site Status 37 • D E F G H I J N O P R S T V W X Z •

Source of Geohydrologic Data ① 36 • Pump Used 35 • Date of First Construction Completion 21 • / / (month day year)

OWNER IDENTIFICATION (1)

R • 158 • T • A D M • (add, delete, modify) Date of Ownership 159 = / / (month day year)

Name: Last 161 = First 162 • Middle Initial 163 •

OTHER SITE IDENTIFICATION NUMBERS (1)

R • 189 • T • A D M • (add, delete, modify) Ident 190 = Assigner 191 •

New Card Same R & T Ident 190 = Assigner 191 •

SITE VISIT DATA (1)

R • 186 • T • A D M • (add, delete, modify) Date of Visit 187 = / / (month day year) Name of Person 188 •

FIELD WATER QUALITY MEASUREMENTS (1)

R • 192 • T • A D M • (add, delete, modify) Date 193 = / / (month day year) Geohydrologic Unit 195 =

New Card Same R thru 195

Temperature 196 = 0,0,0,1,0 • Degrees C 197 •

Conductance 196 = 0,0,0,9,5 • μ Mhos 197 •

Other (STORET) Parameter 196 = • Value 197 •

Other (STORET) Parameter 196 = • Value 197 •

FOOT NOTES

① Source of Data Codes

A	D	G	L	M	O	R	S	Z
other gov't	driller	geologist	logs	memory	owner	other reported	reporting agency	other

FIG. 3 Example of a Borehole or Well Schedule Form

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NOTE 8—The time required to reach equilibrium can be reduced by removing or adding liquid until the liquid level is close to the estimated stabilized level.

8.2 Use one of the following two procedures to determine the stabilized liquid level.

8.2.1 *Procedure 1*—Take a series of liquid-level measurements until the liquid level remains constant with time. As a minimum, two such constant readings are needed (more readings are preferred). The constant reading is the stabilized liquid level for the borehole or well.

NOTE 9—If desired, the time and level data could be plotted on graph paper in order to show when equilibrium is reached.

8.2.2 *Procedure 2*—Take at least three liquid-level measurements at approximately equal time intervals as the liquid level changes during the approach to a stabilized liquid level.

8.2.2.1 The approximate position of the stabilized liquid level in the well or borehole is calculated using the following equation:

$$h_o = \frac{y_1^2}{y_1 - y_2}$$

where:

h_o = distance the liquid level must change to reach the stabilized liquid level,

y_1 = distance the liquid level changed during the time interval between the first two liquid-level readings, and

y_2 = distance the liquid level changed during the time interval between the second and the third liquid level readings.

8.2.2.2 Repeat the above process using successive sets of three measurements until the h_o computed is consistent to the accuracy desired. Compute the stabilized liquid level in the well or borehole.

NOTE 10—The time span required between readings for Procedures 1 and 2 depends on the permeability of the earth material. In material with comparatively high permeability (such as sand), a few minutes may be sufficient. In materials with comparatively low permeability (such as clay), many hours or days may be needed. The user is cautioned that in clayey soils the liquid in the borehole or well may never reach a stabilized level equivalent to the liquid level in the earth materials surrounding the borehole or well.

9. Report

9.1 For borehole or well liquid-level measurements, report, as a minimum, the following information:

9.1.1 Borehole or well identification.

9.1.2 Description of reference point.

9.1.3 Distance between reference point and top of borehole or land surface.

9.1.4 Elevation of top of borehole or reference point (if the borehole or well liquid level is reported as an elevation).

9.1.5 Description of measuring device used, and graduation.

9.1.6 Procedure of measurement.

9.1.7 Date and time of reading.

9.1.8 Borehole or well liquid level.

9.1.9 Description of liquid in borehole or well.

9.1.10 State whether borehole is cased, uncased, or contains a monitoring (observation) well standpipe and give description of, and length below top of borehole of, casing or standpipe.

9.1.11 Drilled depth of borehole, if known.

9.2 For determination of stabilized liquid level, report:

9.2.1 All pertinent data and computations.

9.2.2 Procedure of determination.

9.2.3 The stabilized liquid level.

9.3 *Report Forms*—An example of a borehole or well-schedule form is shown in Fig. 1. An example of a liquid-level measurement form, for recording continuing measurements for a borehole or well, is shown in Fig. 2. An example of a borehole or well schedule form designed to facilitate computer data storage is shown in Fig. 3.

10. Precision and Bias

10.1 Borehole liquid levels shall be measured and recorded to the accuracy desired and consistent with the accuracy of the measuring device and procedures used. Procedure A multiple measurements by wetted tape should agree within 0.02 ft (6 mm). Procedure B multiple measurements by electrical tape should agree within 0.04 ft (12 mm). Procedure C multiple measurements by tape and sounding weight should agree within 0.04 ft (12 mm). Garber and Koopman **(2)** describe corrections that can be made for effects of thermal expansion of tapes or cables and of stretch due to the suspended weight of tape or cable and plumb weight when measuring liquid levels at depths greater than 500 ft (150 m).

REFERENCES

(1) "*National Handbook of Recommended Methods for Water Data Acquisition—Chapter 2—Ground Water*", Office of Water Data Coordination, Washington, DC, 1980.

(2) Garber, M. S., and Koopman, F. C., "Methods of Measuring Water Levels in Deep Wells," *U.S. Geologic Survey Techniques for Water Resources Investigations*, Book 8, Chapter A-1, 1968.

(3) Hvorslev, M. J., "Ground Water Observations," in *Subsurface Exploration and Sampling of Soils for Civil Engineering Purposes*, American Society Civil Engineers, New York, NY, 1949.

(4) Zegarra, E. J., "Suggested Method for Measuring Water Level in Boreholes," *Special Procedures for Testing Soil and Rock for Engineering Purposes, ASTM STP 479*, ASTM, 1970.

(5) "Determination of Water Level in a Borehole," CSA Standard A 119.6 - 1971, Canadian Standards Association, 1971.

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APPENDIX B

FIGURE 1 - Site Plan